PILE DRIVING ANALYZER 6-7-05

1.0 GENERAL

This special provision governs driving piles with a pile dynamic analyzer (PDA) in accordance with the plans and as directed by the Engineer. The PDA test method is described in ASTM D 4945-00, "Standard Test Method for High-Strain Dynamic Testing of Piles". Install piles in accordance with Section 450 of the Standard Specifications and this special provision.

Submit the proposed pile driving equipment in accordance with the Standard Specifications. The Engineer will respond with preliminary approval or rejection of the proposed pile driving equipment within ten (10) calendar days. Preliminary approval of the proposed pile driving equipment by the Department is required before driving piles with a PDA. Notify the Engineer of the pile driving schedule a minimum of fourteen (14) calendar days in advance.

Either an approved PDA Consultant or the NCDOT Geotechnical Engineering Unit, as directed by the Engineer, must perform PDA testing. The Engineer may require the Contractor to retain a PDA Consultant to provide PDA testing. If the Contractor is required to retain a PDA Consultant, contact the Geotechnical Engineering Unit Contract Administrator for a list of approved PDA Consultants.

The Engineer will determine the number of piles and which piles to be tested with the PDA based upon the subsurface conditions and the pile installation sequence and progress.

The Engineer will complete the review of the proposed pile driving equipment and, when noted on the plans, determine the required pile lengths (order lengths) within ten (10) calendar days after the Engineer receives the complete PDA report or the Geotechnical Engineering Unit completes the PDA testing. A PDA report for or PDA testing on multiple piles may be required as directed by the Engineer before the 10 day time period begins.

2.0 PREPARATION FOR PDA TESTING

Provide piles for PDA testing that are 5 ft (1.5 m) longer, or as directed by the Engineer, than the estimated pile lengths shown on the plans. Supply 110 V, 60 Hz, 30 Amp of AC electrical power to operate the PDA equipment. Direct current welders or non-constant power sources are unacceptable.

Provide a suitable shelter to protect the PDA equipment and operator from conditions of sun, water, wind and temperature. The shelter should have a minimum floor size of 6 ft x 6 ft (2 m x 2 m) and a minimum roof height of 8 ft (2.5 m). If necessary, heat or cool the shelter to maintain a temperature between 50 and 85 degrees F (10 and 30 degrees C). Place the shelter within 75 ft (23 m) of the pile such that the PDA cables reach the computer and the operator can adequately see the pile. The Engineer may waive the shelter requirement if weather conditions allow.

Drill up to a total of sixteen (16) bolt holes in either two or four sides of the pile, as directed by the PDA Consultant or the Engineer, at an approximate distance equal to three (3) times the pile diameter below the head of the pile. If the PDA Consultant or the Engineer choose to drill the bolt holes, provide the necessary equipment, tools and assistance to do so. A hammer drill is required for concrete piles and up to two (2) hours may be required to drill the holes.

Lift, align and rotate the pile to be tested with the PDA as directed by the PDA Consultant or the Engineer. Place the pile in the leads and template so that the PDA instruments and their accompanying wires will not be damaged.

The PDA Consultant or the Engineer will furnish the PDA measuring instruments and materials for installing the instruments. Attach the PDA instruments as directed by the PDA Consultant or the Engineer after the pile is placed in the leads and the template.

3.0 PDA TESTING

Use only the preliminarily approved pile driving equipment to drive piles with the PDA instruments attached. Drive the pile as directed by the PDA Consultant or the Engineer in order to measure the wavespeed of the pile.

Drive the pile to the required minimum bearing capacity or tip no higher than elevation, whichever is lower, as shown on the plans or as directed by the PDA Consultant or the Engineer. During pile driving, the PDA will be used to evaluate, including but not limited to, the following: hammer performance, bearing capacity, distribution of soil resistance, pile driving stresses, energy transfer, pile integrity and soil variables including quake and damping.

The PDA Consultant or the Engineer may require the Contractor to modify the pile installation procedure during driving as follows:

- Reduce the hammer energy
- Drive deeper or shallower because of variations in the subsurface conditions
- Readjust the transducers
- Realign the pile

The Contractor is responsible in terms of both actual expense and time delays for any damage to the PDA instruments and supporting equipment due to the Contractor's fault or negligence. Replace any damaged equipment at no additional cost to the Department.

4.0 REDRIVING PILES

The Engineer may require redriving piles with the PDA instruments attached. When directed by the Engineer, wait a minimum 24 hours and then redrive the pile in accordance

with Section 3.0 above. Notify the Engineer of the pile redriving schedule at least one (1) work day before beginning redriving.

Use the same preliminarily approved pile driving equipment and the compressed pile cushion from the initial drive to redrive the pile. Do not use a cold diesel hammer for a redrive, unless in the opinion of the Engineer, it is impractical to do otherwise. In general, warm up the hammer by applying at least twenty (20) blows to a previously driven pile or timber mats on the ground. Reattach the instruments and obtain the required stroke and minimum amount of penetration (at least 6 in or 150 mm) or as directed by the PDA Consultant or the Engineer. The PDA Consultant or the Engineer will record dynamic measurements during redriving.

The Engineer may require redriving more than once on the same pile. The Engineer will determine when PDA testing has been satisfactorily completed.

5.0 CAPWAP ANALYSIS AND PDA REPORT

The PDA Consultant must perform analysis of the PDA raw data with the Case Pile Wave Analysis Program (CAPWAP). At a minimum, analysis is required for a hammer blow near the end of initial drive and for a redrive hammer blow. Additional CAPWAP analysis may be required as determined by the PDA Consultant or the Engineer.

Submit the PDA report to the Engineer in both electronic and hard copy form, including two (2) original hard copies, within seven (7) calendar days after the PDA testing is completed. The PDA report must include but not be limited to the following:

A. Title Sheet
   - NCDOT TIP number and WBS element number
   - Description of the project
   - County
   - Bridge station number
   - Location of the pile(s) tested with the PDA
   - Name of the personnel
   - Date of the report

B. Introduction

C. Site and Subsurface Conditions (including water table elevation)

D. Pile Details
   - Pile types and lengths
   - Pile design loads (minimum bearing capacity)
   - Concrete compressive strength and/or steel pile yield strength

- Pile splice types and locations
- Pile batter (if applicable)

E. Driving Details

- Hammer make, model and type
- Hammer efficiency and operation data including fuel settings, bounce chamber pressure, blows per minute, equipment volume and pressure (if applicable)
- Ground or mud line elevation and template reference elevation at the time of driving (if applicable)
- Final pile tip elevation
- Driving resistance (ram stroke, blows per foot (0.3 meter) and set for last ten hammer blows)
- Use of vibrating hammer, jetting, predrilling and/or spudding (if applicable)
- Redrive information (if applicable)

F. PDA field work details

G. CAPWAP analysis results

- Table showing percent skin and tip, skin and toe damping, skin and toe quake and match quality

H. Summary/Conclusions

I. Attachments

- Boring log(s)
- Field pile driving inspection data (from project inspector)
- Accelerometer and strain gauge locations
- Accelerometer and strain gauge serial numbers and calibration information
- PDA hardware model and CAPWAP software version information
- Electronic copy of all PDA raw data and executable CAPWAP input and output files
- Hammer data

6.0 MEASUREMENT AND PAYMENT

The complete and accepted PDA testing will be paid for at the unit bid price for "PDA Testing" per pile. The unit bid price for conducting PDA testing includes all costs for providing the PDA, PDA instruments and materials for installing the instruments and recording the dynamic measurements during pile driving and redriving. Also include in this unit bid price all costs for performing the CAPWAP analysis and preparing and

submitting the PDA report. No payment for "PDA Testing" will be made if the PDA report submitted is incomplete as described in Section 5.0. No payment for "PDA Testing" will be made if the NCDOT Geotechnical Engineering Unit performs PDA testing.

The complete and accepted PDA assistance will be paid for at the unit bid price for "PDA Assistance" per pile. Include in the unit bid price for "PDA Assistance" all costs for PDA preparation and support including all materials, labor, tools, equipment, mobilization and incidentals necessary to complete the work described in this special provision excluding the costs for the PDA testing described above. Costs for PDA preparation and support for redrives will not be paid for separately. These costs should be included in the unit bid price for "PDA Assistance".

The cost for the pile will be paid for separately in accordance with the Standard Specifications and will not be part of either of these PDA pay items.